PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Apparatus for Measuring the Movement of Valve Needles, particularly for Fuel Injection Nozzles of Internal Combustion Engines.

We, DAIMLER-BENZ AKTIENGESELLSCHAFT, of Stuttgart-Untertürkheim, Germany, a Company incorporated under the laws of Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention concerns apparatus for measuring the movement of valve needles, particularly but not exclusively valve needles in fuel-injection nozzles of internal combustion engines.

According to the invention, in apparatus for the purpose set forth, a rearward portion of the needle itself or a rearward prolongation connected to the said needle serves as a plunger member of a variable-inductance or variable-capacitance transmitter for producing measurement impulses in an electrical measuring and indicating system. The measuring and indicating system employed is preferably one working in *per se* known manner with carrier-frequency modulation, the transmitter being so connected to a measuring bridge circuit of the said system that the carrier frequency is modulated by the effect of the measurement impulses.

Such apparatus, in which the measurement impulses are obtained directly from the valve needle, permits the needle movement in an injection nozzle to be accurately recorded during the operation of the internal combustion engine, showing all the irregularities which may occur.

Two embodiments of the invention are illustrated by way of example in the accompanying drawing, in which:

Figure 1 is a longitudinal section of an injection nozzle for an internal combustion engine.

Figure 2 a longitudinal section of another injection nozzle, and

Figure 3 a circuit diagram of apparatus for the measurement of the movement of the valve needles of such nozzles.

The injection nozzle shown in Figure 1 corresponds in its general construction to the ordinary injection nozzles in commercial use. Its body comprises two outer screw-connected parts 1 and 2 which enclose a needle guide 3 having fuel-supply passages 4, 4*a*. The part 2, having a further fuel-supply passage 4*b*, is closed at the top by a screw cap 5 having a fuel-supply passage 4*c*. The inwardly opening valve needle 6 of the nozzle seats with its tip 6*a* against the inside of the injection orifice of the nozzle. Its upper end is stepped down to a smaller diameter at 6*b* and carries an intermediate part 7 which serves as an abutment plate on which the needle-restoring spring 8 directly bears. The upper end of the spring 8 abuts against a plate 9 having a pot-shaped middle part 9*a* extending downwardly inside the spring. Two coils 10, 10 are disposed one above the other in the pot-shaped part 9*a*. A plunger core 11 of soft iron extending into these coils is connected at its lower end to the adjacent end of the intermediate part 7. The core 11 also extends into a part 12 which is disposed above the plate 9 and projects into the cap 5. The core 11 has an intermediate non-ferrous section 11*a*, for example of brass, which is located, in the mean position of rest of the core, in a mid position in relation to the coils 10, 10, so that the magnetisable sections extend approximately equally far into each of the coils. The coils 10, 10 are connected in the measuring limbs of a bridge B (Figure 3) forming part of an electrical measuring and indicating system working with carrier-frequency modulation. The bridge B is supplied with carrier frequency by an oscillation generator G and is followed by an amplifier V. The latter is followed by a demodulator D and filter circuit S, the output of which is led to an oscillograph O.

The mode of operation of the arrangement described is as follows:—

Fuel pressure produced in the passage 4*c* is

propagated through the passages $4b$, $4a$, and 4 into a chamber 13 near the lower end of the valve needle 6 and causes the needle to move upwards, stressing the spring 8, to open the injection orifice. When the pressure in the passage $4c$ and the chamber 13 decreases, the spring 8 causes the valve needle 6 to close the injection orifice. The part 7 and the plunger core 11, $11a$ partake in the movement of the needle 6. Each movement of the core results in a variation of the inductance of the coils 10, 10 and the combination of parts 10, 11 acts as a transmitter of measurement impulses by which the carrier frequency is modulated. The effect of the impulses is recorded on the oscillograph O in the form of a rising and falling curve. The height of the deflection recorded with reference to a predetermined base line corresponds to a certain scale, to the stroke of the valve needle 6.

The stroke of the needle valve can be similarly measured in the nozzle shown in Figure 2. In this nozzle, in which the outwardly opening valve needle 14 is held in the closed position by the pressure of a spring 15, the plunger core 11, $11a$ is connected as an extension to the rear end of the stem part $14a$ of the valve needle. The valve needle and the adjacent part of the core may be made in one piece. An intermediate part 16 containing the coils, 10, 10 is secured by a screw ring 17 in a part 18 of the nozzle body which also comprises two further screw-connected parts 19 and 20. Leads are brought in to the coils, 10, 10 through screw plugs 21, 22 forming a seal and through insulating inserts 30 and 31. The insert 30 serves at the same time as a pressure-tight seal. The leads may alternatively be brought in from the side. The pressure of the fuel entering at 23 is propagated to a space 27 where it acts on the guide head 28 of the valve needle and lifts the valve off its seat, stressing the spring 15. The plunger core 11, $11a$ moves with the valve needle 14, $14a$ and its movement is indicated by the oscillograph as is the case of the nozzle illustrated in Figure 1.

Instead of a winding comprising two coils, it is possible to use a single coil, but two coils are to be preferred on account of the temperature-compensation effect obtainable. Variation in the ohmic resistance of the coils should also be taken into account by winding the coils, wholly or in part, from materials having opposite temperature co-efficients of resistance or from a material having a very low such co-efficient.

Instead of using a variable-inductance measurement-impulse transmitter, it is possible to employ a variable-capacitance transmitter. The coils of the former are then replaced by tubular condensers into which a plunger member penetrates.

What we claim is:—

1. Apparatus for the measurement of the movement of a valve needle, particularly in a fuel-injection nozzle of an internal combustion engine, wherein a rearward portion of the needle itself or a rearward prolongation connected to the said needle serves as a plunger member of a variable-inductance or variable-capacitance transmitter for producing measurement impulses in an electrical measuring and indicating system.

2. Apparatus according to claim 1, wherein the transmitter is connected to a measuring bridge-circuit of a measuring and indicating system working with carrier-frequency modulation.

3. Apparatus according to claim 1 or 2, wherein the stationary member of the transmitter comprises a winding which is inserted in the body of the valve or nozzle and into which the rearward portion or prolongation of the needle penetrates.

4. Apparatus according to claim 3, wherein the winding is composed of two coils arranged one behind the other and the plunger member is made double-acting, for which purpose it comprises two magnetisable core sections separated from each other by a non-magnetisable section which, in the mean position of rest of the plunger member, is located at the middle of the coils while the magnetisable sections penetrate equally far into respective coils from the outside.

5. Apparatus according to claim 3 or 4, wherein the winding is disposed in a pot-like insert, which may at the same time serve as abutment for a needle-restoring spring disposed in the body.

6. Apparatus according to any one of claims 3 to 5, wherein the winding is composed of materials having opposite temperature co-efficients of resistance or of a material having a very low such coefficient.

7. Apparatus according to any one of claims 3 to 6, wherein lead-in means for bringing the connections to the transmitter into the valve or nozzle body serves also as a pressure-tight seal for the said body.

8. Apparatus according to claim 1 or 2, wherein the transmitter comprises tubular condensers into which the plunger member penetrates.

9. Apparatus for measuring the movement of a valve needle substantially as described with reference to the accompanying drawing.

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754,917 COMPLETE SPECIFICATION
1 SHEET

This drawing is a reproduction of the Original on a reduced scale.

Fig. 1

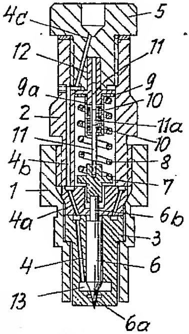

Fig. 2

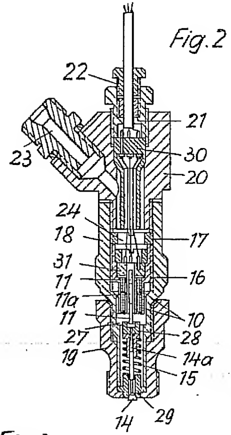

Fig. 3